



# ***SITE Technology Capsule*** **Multi-Vendor Bioremediation Demonstration Project: Environmental Laboratories/ SBP Technologies' UVB Vacuum Vaporization Well Process**

## **Abstract**

The UVB process was developed by IEG Technologie GmbH of Germany and licensed in the eastern U.S. by Environmental Laboratories, Inc. (ELI) and SBP Technologies, Inc. (SBP). A modified microbial system employing an in-well biofilter was demonstrated under the SITE Program at the Sweden-3 Chapman landfill in Sweden, New York, along with the ENSR/Larsen Biovault technology and the R. E. Wright Environmental, Inc. In Situ Bioventing System, as part of a Multi-Vendor Bioremediation Demonstration.

A single wide bore UVB-400 well (Vacuum Vaporization Well) equipped with a biofilter was used in the demonstration. Groundwater was circulated through the well and is returned, presumably with an increased microbial population, to the saturated zone for further in situ biodegradation of volatile organic compounds (VOCs). An aboveground blower assists circulation of air, provides oxygen for biodegradation, and strips volatiles from the vadose zone. Extracted volatiles were treated by an ex situ vapor phase biofilter followed by activated carbon. The developers estimated that the single well would influence a soil volume of approximately 1000 yd<sup>3</sup>.

A primary objective of the demonstration was to determine the effectiveness of the UVB Process in reducing the concentrations of six target VOCs in the vadose zone soil to below New York State Department of Environmental Conservation (NYSDEC) Soil Cleanup Criteria (acetone: 0.2 ppm, methyl ethyl ketone: 0.6 ppm, 4-methyl-2-pentanone: 2 ppm, cis-1,2-dichloroethene: 0.6 ppm, trichloroethene: 1.5 ppm, and tetrachloroethene: 2.5 ppm). ELI/SBP expected that 90% of the soil samples collected from the vadose zone of the 50 ft x 50 ft test area would meet the NYSDEC Criteria for the six target contaminants after six months (one season) of treatment. A second primary objective was to evaluate the developers' claim that biodegradation would be the dominant mechanism of contaminant removal, but all participants agreed that this claim could only be evaluated qualitatively because of limitations in the sampling procedures. Assessing the effectiveness of the process in reducing groundwater contamination by VOCs was a secondary objective of the study.

Because of the time required to establish the convection loop coupled with operational and site problems, the investigation was extended from 5.5 months to 14 months. After 5.5 months, only 65% of approximately 50 soil



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samples from both vadose and saturated zones met the NYSDEC Criteria, and only 70% met the Criteria after 14 months. Nevertheless, significant removal of the ketones appeared to take place over the 14-month study.

Analytical results and other observations suggest that both biodegradation and stripping were important mechanisms for VOC removal from the soil. Groundwater concentrations of VOCs also decreased over time, but neither the extent of removal nor the removal mechanism could be ascertained from the demonstration data.

## Introduction

In 1980, the U.S. Congress passed the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), also known as Superfund. The Act is committed to protecting human health and the environment from uncontrolled hazardous waste sites. CERCLA was amended by the Superfund Amendments and Reauthorization Act (SARA) in 1986 - amendments that emphasize the achievement of long-term effectiveness and permanence of remedies at Superfund sites. SARA emphasizes the use of permanent solutions, alternative treatment technologies, or resource recovery technologies, to the maximum extent possible, to clean up hazardous waste sites.

State and federal agencies, as well as private parties, are now exploring a growing number of innovative technologies for treating hazardous wastes. The sites on the National Priorities List total over 1,200 and comprise a broad spectrum of physical, chemical, and environmental conditions requiring varying types of remediation. The U.S. Environmental Protection Agency (EPA) has focused on policy, technical, and informational issues related to exploring and applying new remediation technologies applicable to Superfund sites. One such initiative is EPA's Superfund Innovative Technology Evaluation (SITE) program, which was established to accelerate development, demonstration, and use of innovative technologies for site cleanups. EPA SITE Technology Capsules summarize the latest information available on selected innovative treatment, site remediation technologies, and related issues. These capsules are designed to help EPA remedial project managers and on-scene coordinators, contractors, and other site cleanup managers understand the types of data and site characteristics needed to effectively evaluate a technology's applicability for cleaning up Superfund sites.

The Multi-Vendor Bioremediation Demonstration was a unique SITE project in that it was a cooperative effort between the USEPA, NYSDEC, the New York State Center for Hazardous Waste Management, and three developers. This demonstration evaluated three bioremediation technologies: 1) UVB Vacuum-Vaporized Well System - Environmental Laboratories/SBP Technologies, Inc.; 2) In situ Bioventing System - R.E. Wright Environmental, Inc.,

and 3) Biovault Treatment Process - ENSR/Larsen. A more detailed Innovative Technology Evaluation Report (ITER) will be available for each of the three studies.

This capsule contains information on the ELI/SBP UVB Treatment Process, a system designed to provide bioremediation for groundwater and permeable soils (saturated and vadose) contaminated with VOCs. The technology was evaluated under EPA's SITE program from July 1994 to September 1995. The pilot-scale demonstration was conducted at the Sweden-3 Chapman landfill site in Sweden, New York where soils and groundwater were found to be contaminated with trichloroethene (TCE), tetrachloroethene (PCE), cis-1,2-dichloroethene (cis-DCE), acetone, 2-butanone (MEK), 4-methyl-2-pentanone (MIBK), toluene, and other aromatic compounds.

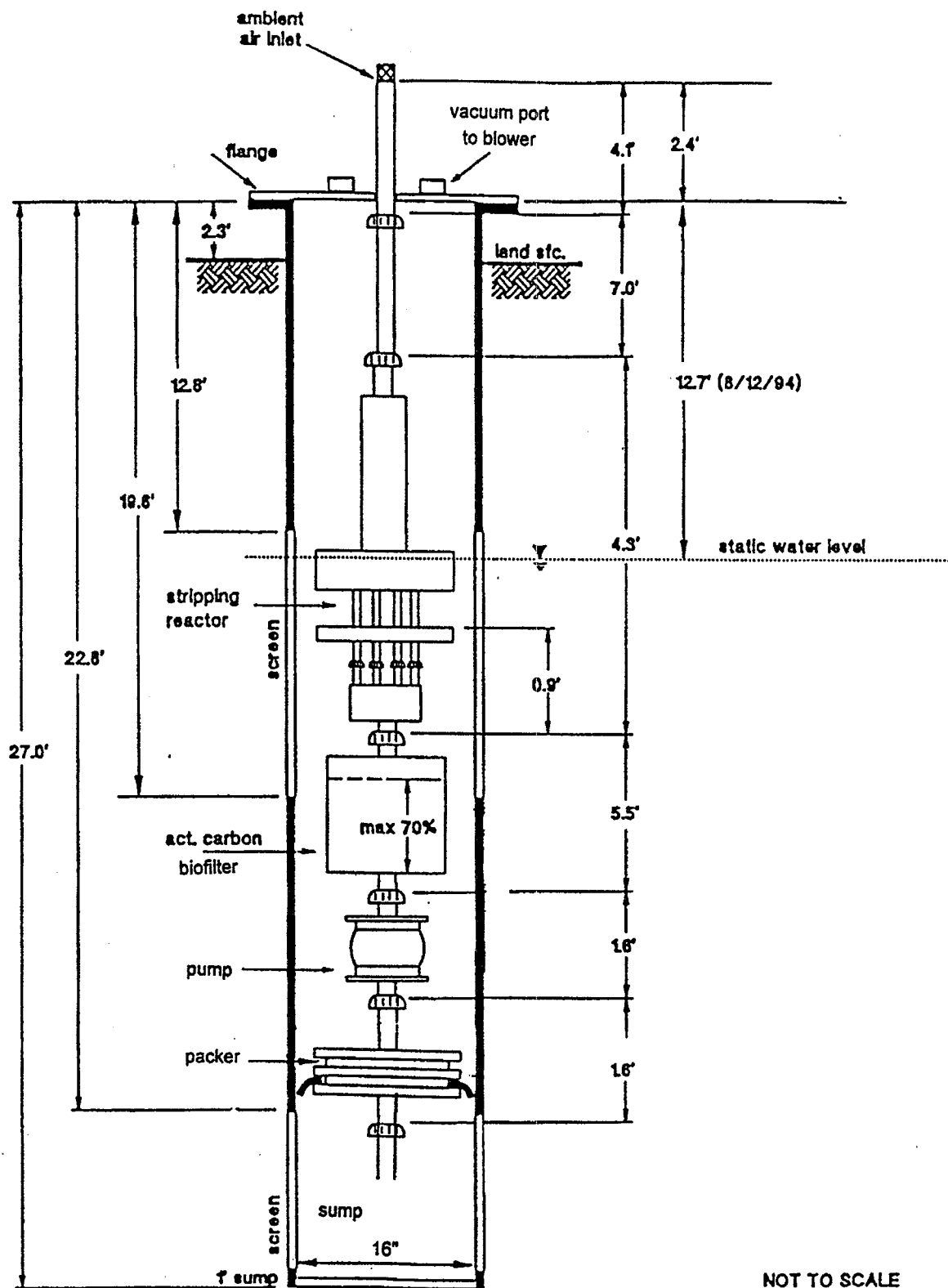
Information in this Capsule emphasizes specific site characteristics and results of the SITE field demonstration of the ELI/SBP UVB Treatment Process at the Sweden-3 Chapman site. This capsule presents the following information:

- Abstract
- Technology description
- Technology applicability
- Technology limitations
- Process residuals
- Site requirements
- Performance data
- Technology status
- Sources of further information

## Technology Description

According to the developers, the Unterdruck Verdampfer Brunnen (German for Vacuum Vaporization Well) or UVB technology combines air stripping and biodegradation in both the soil formation and a well to remove VOCs from soils. The system used at the site (Figure 1) consisted of an aboveground blower connected to a specially adapted wide bore groundwater well. The system in the well included a negative-pressure stripping reactor, located above the expected seasonal high water table, on top of an integrated bioreactor (fixed film activated carbon bioreactor with slow-release inorganic nutrients). To allow for fluctuations in the water table, a submersible pump was included to insure a constant supply of groundwater to the bioreactor. Groundwater flow is controlled by screening the well casing in two areas; near the expected water table surface and near the bedrock, and by placing a submersible pump near the base. A packer separates the lower screened portion from the upper portion and forces groundwater to pass through the biofilter.

In operation, the aboveground blower induces a suction in the stripper, drawing in ambient air through a centrally



NOT TO SCALE

Drawing revised 8/16/94  
based on 8/13/94 site visit

Figure 1. Schematic of UVB System

located pipe as well as from the surrounding vadose zone while raising the level of water already present in the well. The ambient air infiltrating the surrounding soil formation captures VOCs that may volatilize. Infiltration also increases the oxygen concentration of the groundwater/soil matrix and stimulates indigenous microbes to enhance the biodegradation of contaminants. The ambient air also bubbles through the raised groundwater, sparging or stripping VOCs in the process. The VOC-laden air is then exhausted through a combination of ex situ, vapor-phase bioreactors and activated carbon filters on the positive pressure side of the blower to minimize VOC emissions to the atmosphere.

After treatment in the stripper reactor, the elevated groundwater is discharged into the upper soil stratum and percolates back to its natural level, again picking up contaminants from the soil matrix. Thus, a groundwater circulation loop is established. This circulation cell constantly transports contaminants, nutrients, oxygen and indigenous bacteria through the affected soil. The contribution of the physical "stripping" effect as compared to the biological effect varies according to site specific conditions (e.g., water table depth, air and water permeability, indigenous microbe characteristics, etc.).

According to ELI/SBP, dewatering is not essential for efficient operation of this system. Treatment of the phreatic and capillary fringe zones also occurs simultaneously. The system can be operated in either a standard mode as described above and used for the demonstration, or in a reverse-flow circulation mode by the addition of a pump; flow modes can be readily converted in the field.

The developers suggest several means of enhancing the biodegradation. The fixed film indigenous microflora used by the bioreactor can be augmented with other types of contaminant-degrading microbes, depending on site conditions and contaminants. Degradation also can be stimulated by the addition of either liquid or gaseous inorganic nutrients and/or alternative electron acceptors. Finally, injection of heated air can enhance both VOC desorption and the rate of biodegradation of organic contaminants. This would be particularly useful in regions normally subject to cold winter climates. These concepts were not evaluated during this demonstration.

## Technology Applicability

The UVB Microbial Treatment Process was evaluated based on the nine criteria used for decision making as part of the Superfund Feasibility Study (FS) process. Results of the evaluation are summarized in Table 1.

The ELI/SBP UVB system is designed to treat vadose and saturated zone soils and groundwater contaminated with VOCs and semivolatiles. The chemical and physical dynamics established by the recirculation of treated water make this technology suited for remediation of contaminant

source areas. The technology employs readily available equipment and materials, and the material handling requirements and site support requirements are minimal, according to the developers.

## Technology Limitations

According to ELI/SBP, the UVB system is most appropriate for treatment of sites with good hydraulic conductivity in the saturated zone and high air permeability in the vadose zone. Good hydraulic conductivity in the saturated zone accelerates the establishment of a circulation cell for faster and more effective cleanup. High air permeability in the vadose zone increases the volatilization of contaminants, improves the supply of oxygen to indigenous microbes for enhanced biological degradation, and increases the air supply to the in situ stripper reactor for better performance while reducing the size of the blower required and lowering overall remediation costs.

The effectiveness of the technology may be limited for soils contaminated with high concentrations of heavy metals that could be toxic or could inhibit biological performance. Types and concentrations of metals present as well as any other compounds that may be toxic to the indigenous soil microbes need to be assessed at each site under consideration.

In areas with very shallow groundwater (less than 5 ft), it may be difficult to establish contact between the gas and aqueous phases long enough to remove contaminants. The technology has further limitations in thin aquifers (less than 10 ft); the saturated zone must be of sufficient thickness to allow proper installation of the well system. In addition, the thickness of the saturated zone affects the radius of the circulation cell; the smaller the aquifer thickness, the smaller the radius of the circulation cell and consequently the larger the number of wells required.

The majority of the water being drawn from the aquifer into the lower screened section is treated water re-infiltrating from the upper section. As the UVB system continues to operate, the circulation cell expands until a steady state is reached. As the circulation cell grows, the amount of recirculated water increases, causing a significant decrease in contaminant concentrations in the water being treated by the system. This can potentially have an adverse effect on the performance of both the bioreactor and stripper, since their performance is concentration dependent.

Conversely, high concentrations of volatile compounds may require multiple passes through the system to achieve remediation goals. This may be a problem since a portion of the treated water is not captured by the system and continues to leave the circulation cell in the downgradient direction. However, once the UVB circulation cell is established, the influent concentrations should be diluted to below levels requiring more than one pass, thereby

**Table 1. FS Criteria Evaluation for UVB In Situ Bioremediation Treatment Process**

<b>Criteria</b>	<b>UVB Performance</b>
Overall Protection of Human Health and the Environment	Provides both short- and long-term protection by eliminating organic contaminants in soil. Prevents further groundwater contamination and minimizes off-site migration. Minimal emissions and discharges during installation and operation.
Compliance with Federal ARARs	Requires compliance with RCRA treatment, storage, and land disposal regulations (of a hazardous waste) particularly during installation. Installation and operation require compliance with location-specific ARARs. Emission controls may be needed to ensure compliance with air quality standards if VOCs are present.
Long-term Effectiveness and Performance	Has the potential to effectively remove contamination source. May involve some residuals treatment and disposal (e.g., extracted air, well cuttings).
Reduction of Toxicity, Mobility, or Volume through Treatment	Significantly reduces toxicity and mass of soil contaminants by treatment. May distribute organic contaminants through zone of influence.
Short-term Effectiveness	Presents minor short-term risks to workers from air releases during installation of UVB well.
Implementability	Involves few administrative difficulties, other than those associated with well installation. Wells and aboveground system can be constructed in less than 2 weeks. Requires heavy equipment, such as crane, to install and position UVB system.
Cost	\$149/yd <sup>3</sup> based on successful removal of VOCs from 12,800 yd <sup>3</sup> over 14 months. Actual costs of remedial technology are site-specific and dependent on factors such as the cleanup level, contaminant concentrations, soil characteristics, and volume of soil treated.
Community Acceptance	Presents minimal short term risk to community. Public familiar with and comfortable with biotreatment as in wastewater treatment. Some minor, controllable noise from blowers.
State Acceptance	State permits may be required if remediation is part of RCRA corrective action.

limiting the potential migration of contaminants from the system.

The relative sizes of the circulation cell and the contaminant source area will determine the number of wells needed for remediation of a particular site.

As with other biological processes, the ELI/SBP technology could be impacted by low temperatures, which are known to slow biodegradation processes. Extended periods of below freezing temperatures could seriously affect treatment performance. As such, the technology may be better suited to areas with moderate winters, may require a heated enclosure for protection against extreme cold weather conditions, may require the ambient air to be heated, or may be operated on a seasonal basis.

## **Process Residuals**

The materials handling requirements for the UVB system include managing spent activated carbon or residues from other offgas treatment, drilling wastes, purge water, and decontamination wastes generated during installation, operation, and monitoring of the system. Spent carbon generated by offgas treatment can either be disposed of or regenerated by the carbon vendor. Drilling wastes produced during installation of the system well and monitoring wells can be managed either in 55-gallon drums or in roll-off debris bins, depending on quantity and characteristics. Disposal options for this waste depend on state and local requirements and on the presence or absence of contaminants. The options may range from on-site disposal to disposal in a hazardous waste landfill.

Purge water generated during development and sampling of groundwater monitoring wells usually can be stored in

55-gallon drums. Disposal options again depend on state and local restrictions and on the presence or absence of contaminants. Options include surface discharge through a National Pollutant Discharge Elimination System (NPDES) outfall, disposal through a Publicly Owned Treatment Works (POTW), and treatment and disposal at a permitted hazardous waste facility, all with or without on-site pretreatment.

Decontamination wastes generated during installation, decommissioning, and sampling activities include decontamination water. A decontamination pad may be required for the drill rig. Solid decontamination wastes can be managed in roll-off type debris boxes and liquid wastes can be managed in 55-gallon drums. Disposal options are similar to those for drilling wastes and purge water.

## Site Requirements

A UVB microbial treatment system consists of several major components: a dual-screened well, stripping reactor, biofilter, well packer, submersible pump, blower, aboveground vapor phase bioreactors, and carbon adsorption units. A drill rig is required to install and remove the well casing and to install the equipment within the well itself.

The site support requirements needed for the UVB system are potable water, electricity, and space to set up the ex-situ bioreactors and off-gas treatment system. The blower requires standard 440 volts (200 amperes). An electrical pole, a 460-volt 3-phase converter for the operating system, and electrical hookup between the supply lines, pole, and the UVB treatment system are necessary to supply power. The space requirements for the aboveground components of the UVB system, including the UVB system well, off-gas treatment units, blower, and piping used during the SITE demonstration, were approximately 250 square feet. Other requirements for installation and routine monitoring of the system may include access roads for equipment transport, security fencing, and decontamination water and/or steam for drilling and sampling.

The site should be relatively level and clear of obstructions to facilitate well and equipment placement. As noted earlier, vadose and saturated zones should be well defined and should be reasonably consistent from season to season.

## Performance Data

Pilot-scale testing of the UVB-400 in situ process was conducted in a 50 ft x 50 ft plot at the Sweden-3 Chapman landfill in Sweden, New York as part of the Multi-Vendor Demonstration.

A primary objective of the demonstration was to determine the effectiveness of the technology in reducing VOC

contamination in the soil sufficiently to meet NYSDEC Soil Cleanup Criteria. As a remediation goal to evaluate this objective, the developers expected that 90% of the soil samples collected from the anticipated vadose zone in the plot after 5.5 months (nominally one warm season) of operation would be below NYSDEC Cleanup Criteria for six target VOCs (acetone: 0.2 ppm, MEK: 0.6 ppm, MIBK: 2.0 ppm, cis-DCE: 0.6 ppm, TCE: 1.5 ppm, and PCE: 2.5 ppm). In addition, the developers claimed that biodegradation would be the dominant mechanism of contaminant removal from the formation. The developers also expected that groundwater would exhibit significant reductions in VOC concentrations as a result of the recirculation cell through the in situ biofilter. Finally, as an adjunct to the project, the developers also sought to evaluate the effectiveness of ex situ biofilters in removing VOCs from the air extracted from the formation.

To evaluate the primary and secondary objectives, samples from the soil, groundwater, and extracted air streams were collected at intervals starting in July 1994 and continuing to the termination of the project in September 1995. To assure that a maximum number of the soil samples would contain detectable concentrations of the critical VOCs, the plot was first divided into a 3 x 3 grid. Soil borings (2-inch split spoon) from the expected vadose zone (~9 to 15 ft below ground surface, bgs) were first scanned by a field photoionization detector (PID). On the basis of this screening, sixteen additional boring locations were selected to maximize the detection of contamination. It quickly became clear that the vadose and saturated zones were not clearly defined and that the vadose zone was usually much narrower than the anticipated 9 - 15 ft bgs. To overcome some of these unanticipated problems, samples were designated as "vadose" or "saturated" and were analyzed separately. In addition, again to assure maximum contamination, the sample from each 2-foot split spoon section was selected based on a "hot spot" reading by the PID. Consequently, the resulting ~50 samples from the 25 borings obtained during each sampling event cannot be considered to be representative of the site, and may not even be representative of an individual core. Samples were analyzed for VOCs, other contaminants, microbiological activity, and nutrients to assess performance and effectiveness of the system.

When preliminary results indicated that little decrease in soil VOC concentrations was occurring during the first growing season, due to bad weather and operational difficulties or the unique characteristics of the UVB system, the EPA and the NYSDEC agreed to continue the evaluation through a second warm season. Operation of the in situ system was continued through the winter and was assumed, for evaluation purposes, to be continuous for the 14-month test period. Modifications to the system also were made in the Spring of 1995 to accommodate large, unanticipated variations in the water table and to assure that the exhausted air passed through the ex situ

## vapor phase biofilters.

The primary objective (achievement of the NYSDEC Soil Cleanup Criteria) was evaluated by measuring the residual concentrations of the selected VOCs in grab samples from cores obtained from twenty five locations within the test plot at the completion of the first season (~5.5 months) and at the end of the 14-month test period. Although the original intent was to evaluate the effectiveness of the technology for the vadose zone only, a high and variable water table left only a very shallow vadose zone and made it prudent to evaluate changes in both the vadose and the saturated zone.

The second objective, estimating the contribution of biodegradation to overall removal, was assessed by several biological and chemical measurements over the course of the demonstration. In addition to VOC mass removal, other measurements used to assess the extent of biodegradation included: changes in CO<sub>2</sub>, O<sub>2</sub>, cis-DCE and vinyl chloride concentrations, and changes in total heterotroph and TCE-degrading microbial growth in the soil and groundwater. The mass removal of VOCs in the groundwater could not readily be estimated because of factors such as flushing and migration.

Based on the analytical results (Table 2), the developers were not successful in meeting the 90% cleanup objective, even after 14 months. Only 65% of the usable soil samples collected in the plot after 5.5 months and 70% of the samples collected after 14 months met the NYSDEC Cleanup Criteria. (At the outset of the demonstration the calculated compliance was 67%).

As indicated in Table 2, some of the analytical data, primarily for acetone and MEK, could not be utilized because detection limits were higher than the NYSDEC criterion for that contaminant and it could, consequently, not be determined whether these samples met the Criteria. Higher-than-anticipated concentrations of aromatic VOCs (compared to predemonstration data) were a major contributing factor in the high detection limits for the critical analytes.

Table 3 compares initial and final (14 month) calculated masses for the six critical VOCs and toluene, using the Practical Quantitation Limits (PQLs) for "ND" value, and also indicates the relative contribution to VOC removal in the exhausted air. Ketone removals from the soil appear to be more extensive than removal of chlorinated hydrocarbons; cis-DCE results may be ambiguous due to production of this compound by degradation of TCE and/or PCE.

Because of apparent elevated masses of VOCs after 5.5 months, the contribution of biodegradation (if any) to removal could not be estimated. Using calculated values for the masses of each VOC at the 14-month event and the masses of each contaminant removed in the extracted air

Table 2. UVB Compliance with NYSDEC Cleanup Criteria

VOC	Criterion (ppb)	Usable Data Points (#)	Data Points Meeting Criterion (#)	(%)
RESULTS AFTER 5.5 MONTHS				
Acetone	200	11	0	0
MEK	600	12	0	0
MIBK	2000	23	21	91
DCE	600	32	14	44
TCE	1500	31	27	87
PCE	2500	31	29	94
Total		140	91	65
RESULTS AFTER 14 MONTHS				
Acetone	200	19	0	0
MEK	600	25	4	16
MIBK	2000	46	45	98
DCE	600	46	22	48
TCE	1500	46	45	98
PCE	2500	46	44	96
Total		229	160	70

Note: (\*) Data reported as non-detectable were not utilized in the evaluation if the detection limit was above the NYSDEC Criterion.

Developers "credited" with any samples that were uncontaminated initially.

stream and in the knockout water (very small), rough estimates of removal (61-70%) and the potential contribution of biodegradation (94-98%) could be calculated for the ketones, but not for the chlorinated VOCs. The effects of extraction, biodegradation, or flushing by groundwater on any of the contaminants are not included. Degradation of TCE and/or PCE to cis-DCE is another factor that may be affecting the observed values for cis-DCE.

Other data expected to support numerical data do not clarify the interpretation of the results of this demonstration. Oxygen and carbon dioxide concentrations in the extracted air remained essentially unchanged, as expected, because of the intake of ambient air. TCE-degrading microbial populations in the soil and the groundwater were small and decreased over the course of the demonstration, providing little support for biodegradation of the chlorinated VOCs. On the other hand, average total heterotroph populations for the soil samples, with approximately a 7-fold increase over the course of the demonstration, were more indicative of biodegradation; however, total heterotroph populations in groundwater samples decreased over the course of the



**Table 3. VOC Removals by UVB System after 14 Months**

VOC	Mass in Soil (gm)		Mass Removed in Air & Water (gm)	Overall Percent Removal	Percent Potentially Biodegraded
	Initial	Final			
Acetone	3700	960	120	74	71
MEK	6300	2100	58	67	66
MIBK	2200	440	69	80	77
cis-DCE	1900	1200	2200	37	--
TCE	1500	3200	510	--	--
PCE	380	350	120	8	--
Toluene	58000	7400	1900	87	84

demonstration. These observations, the high removal efficiency for the ketones, and the apparent production of cis-1,2-dichloroethene would suggest that some biodegradation is underway, although the evidence is not strong. The detection of significant concentrations of vinyl chloride (VC) in the exhausted air and in groundwater (but not in soil samples) suggests that biodegradation is occurring, but that anaerobic mechanisms rather than the expected aerobic mechanisms may be operative.

Analyses of groundwater samples, particularly those from wells upgradient of the UVB well, indicate significant but variable reductions in VOC contamination over the course of the demonstration, particularly in wells closer to the UVB well. Groundwater well data initially and for each sampling event also indicated that concentrations of all contaminants increased downgradient from the UVB well. The data also indicate that MEK, cis-DCE, toluene and vinyl chloride were the most prominent VOCs, and that the ketones tended to be concentrated in the shallow groundwater while the chlorinated ethenes were concentrated in the deep monitoring wells, as might be anticipated. Vinyl chloride remained at significant concentrations in all wells throughout the 14-month study, suggesting that anaerobic biodegradation was occurring.

Analyses of influent to and effluent from the in situ biofilter indicated that VOC removal was taking place in the biofilter over the course of the demonstration as well as during the short residence time in the biofilter. It is not possible to attribute this to biodegradation or adsorption without more extensive testing.

Due to excessive head loss, the original single, spiral-wound vapor phase biofilter was replaced in April 1995 with two biofilters, each containing seven carbon cartridges. Operating in parallel, the new design produced much lower head loss. Flow and VOC data confirmed that the changes were successful in assuring uniform passage of air through the two trains. Sampling and analysis of the air stream before and after the two redesigned indicate target VOC

removals of about 60% to 75%, but the removal mechanisms cannot be defined.

In general, various aromatic compounds were much more prevalent than the target VOCs in all soil samples. Toluene is included in the data compilations as an example. High concentrations of these aromatic VOCs adversely affected the ability to detect or quantify low concentrations of the target VOCs, but they also may have served as cometabolites for biodegradation - if the concentrations were not high enough to cause toxicity to the biological system.

For the 14-month demonstration, the estimated cost was \$347/yd<sup>3</sup> to treat about 628 yd<sup>3</sup> in the test plot. The cost to remediate approximately 13,000 cubic yards of similarly contaminated vadose zone soil over a 14 month period at the Sweden-3 Chapman site using 22 UVB wells is estimated at \$149/yd<sup>3</sup>. Increasing the treatment time to 3 years or 5 years, as suggested by the developers, increases the cost to \$259/yd<sup>3</sup> and \$375/yd<sup>3</sup>, respectively. Because of the nature of the technology, saturated zone soils and groundwater within the radius of influence would also be treated simultaneously. However, no credit was taken for groundwater treatment in this economic analysis, which focused on vadose zone soil treatment. As the full-scale, 14-month cost analysis was configured, the largest cost categories are site preparation and equipment costs, accounting for 40% and 22% of the costs. Labor accounts for 17% of the costs. As the duration of the remediation increases, the contribution of site preparation costs decreases and the labor cost increases. This technology is typical of other bioremediation processes in that the majority of the costs are in the initial site preparation and startup phases. For this estimate no costs were assigned for permitting and regulatory requirements or facility modification, repair or replacement.



## Technology Status

The UVB microbial technology has been utilized at a number of sites throughout the world, primarily for treatment of BTEX-contaminated groundwater.

## Disclaimer

The data, observations and conclusions presented in this Capsule have been reviewed by EPA's Quality Assurance/Quality Control Office.

## Sources of Further Information

An Innovative Technology Evaluation Report will be available for the UVB technology and for the other two technologies that were evaluated as part of the same

investigation.

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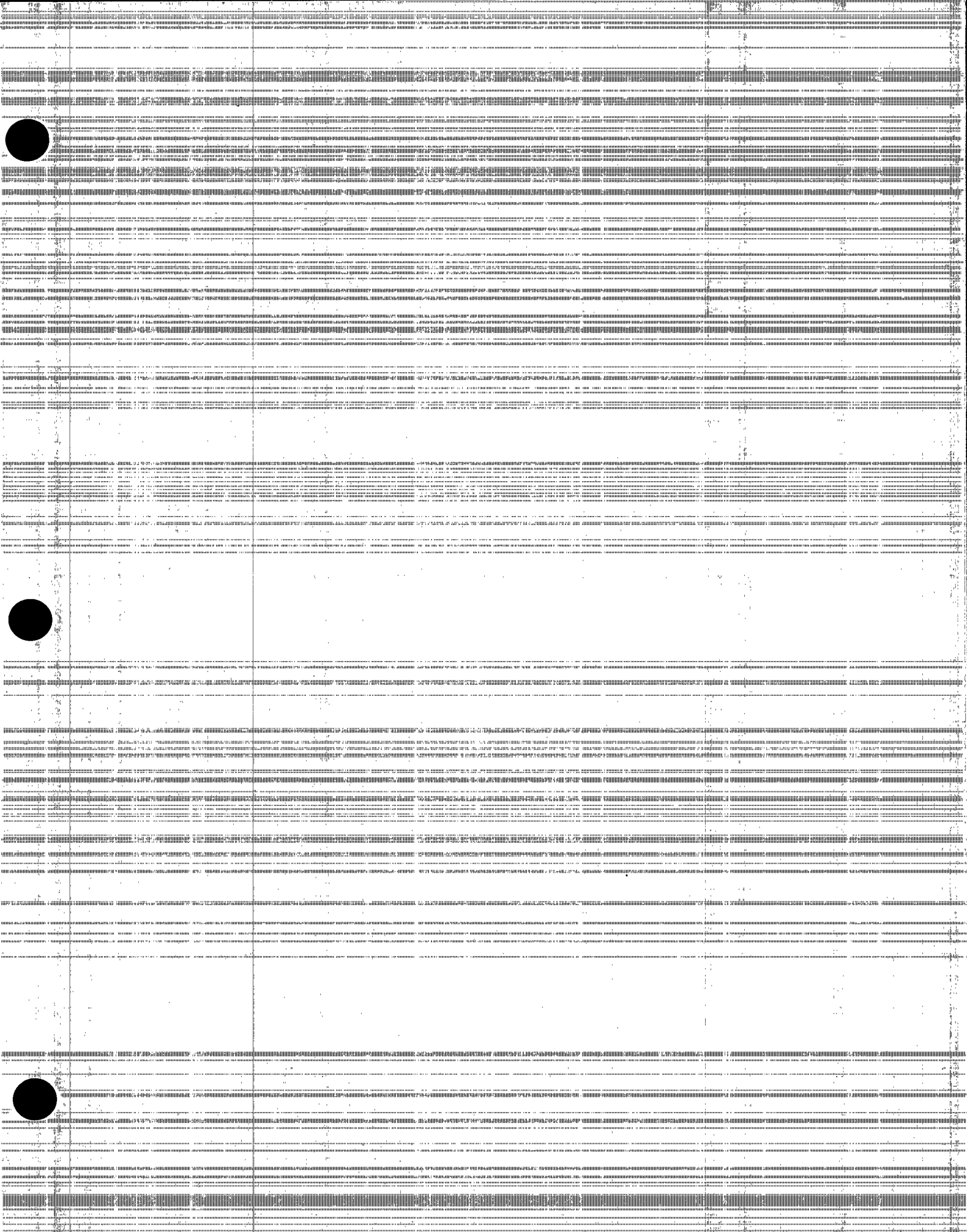
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